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OPERATIONAL DYNAMICS

M.V. ARCTIC SEMINAR 1985

Abstracts of Presentations

Prepared for

Transportation Development Centre
Montreal

November, 1985

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OPERATIONAL DYNAMICS

TP 7235E

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Prepared for
Transportation Development Centre
Montreal

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November, 1985

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The contents of this report reflect the views of the authors and not necessarily the official views or policies of the Transportation Development Centre.

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17. Abstract

This report contains abstracts of the topic presentations given at the M.V. Arctic Seminar 1985 held in Montreal, September 16-17, 1985. The objective of the Seminar was to inform the Canadian marine community of the history and results of the M.V. Arctic research and development program and the thrusts of future activities in this connection.

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17. Résumé

Ce rapport est un résumé des communications présentées lors du Séminaire N.M. Arctic 1985 tenu à Montréal les 16 et 17 septembre 1985 et dont l'objet était d'informer les milieux maritimes canadiens de la recherche qui s'était faite à bord de l'Arctic, ainsi que des résultats obtenus et des perspectives qu'elle a ouvertes dans ce domaine.

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INTRODUCTION

The M.V. Arctic Seminar 1985 was held at the Four Seasons Hotel, Montreal, on September 16 & 17, 1985. Sponsored by the Canadian Marine Transportation Administration in support of the Marine Transportation R & D Advisory Board, the Seminar was organised by the Transportation Development Centre(TDC).

Aimed at senior corporate and government decision-makers, the Seminar reported on the experience gained in commercial arctic shipping through the M.V. Arctic research program. The program commenced in 1978 with the construction and delivery of the Ice Class 2 bulkcarrier M.V. Arctic as a government/industry joint-venture. The ensuing seven-year program was unique in that it provided an opportunity to examine all main aspects of the performance of an ice-breaking cargo vessel whilst engaged on her normal arctic commercial missions.

The knowledge gained represented a special level of circumpolar marine technological and commercial experience, the highlights of which were brought to the attention of the Canadian marine community at the Seminar. The Seminar programme is provided on the next page and is followed, in chronological order, by abstracts of the main presentations.

PROGRAMME

September 15, 1985

1900 - 2200 Registration

September 16, 1985

0730 - 0900 Registration

0900 - 0930 Welcome: Dr. P. Camu, Seminar Chairman
Opening Address: Mr. R.A. Quail, Administrator
Canadian Marine Transportation Administration and
Mr. R Mayes, Director General
Transport Canada, Research & Development

0930 - 1000 Topic: An Arctic Overview
Speaker: Mr. G.N. Faulkner
Assist. Deputy Minister, Indian & Northern Affairs

1000 - 1045 Topic: M.V. Arctic Profile
Speaker: Mr. R.A. Dick, Vice-President
Melville Shipping Limited

1045 - 1100 COFFEE

1100 - 1215 Topic: Propulsive Performance
Speaker: Mr. E. Thompson, Manager of Engineering
Melville Shipping Limited

Propulsion Panel:
Moderator: Mr. I. Bayly, TDC
Panelists: Mr. H. Abruzzese, Director Technical Services
Canada Steamship Lines Inc.
Mr. P. Fensslein, Sales Manager
MAN – GHH (Canada) Inc.

1215 - 1330 LUNCH RECESS

1330 - 1445 Topic: Structural Performance - local effects
Speaker: Mr. I. Glen, President
Arctec Canada Limited

1445 - 1500 COFFEE

1500 - 1615 Topic: Structural Performance - global effects
Speaker: Mr. A. Davidson, Vice-President
German & Milne Inc.
Structural Panel:
Moderator: Mr. R. Bertrand, TDC
Panelists: Mr. F. Taylor, Technical Director
Port Weller Drydock Ltd.
Mr. G. Almond, Principal Ship Surveyor
Lloyd's Register of Shipping (Canada)

1615 - 1630 Closing Remarks: Dr. P. Camu, Chairman
Marine Transportation R&D Advisory Board

1800 - 1900 M.V. Arctic Operators' and Users' Reception - L'Atrium

1900 - 2100 Dinner - Salle Pierre de Coubertin
- Guest Speaker Dr. J. Smith
Assoc. Deputy Minister, Transport Canada

PROGRAMME

September 17, 1985

0830 - 0835 Opening Remarks: Dr. P. Camu, Chairman
Marine Transportation R&D Advisory Board

0835 - 0930 Topic: Ice Transiting Performance - Continuous
Speaker: Mr. A.C. Albery, Senior Partner
Albery, Pullerits, Dickson & Associates

0930 - 1000 Topic: Ice Transiting Performance - Manoeuvering
Speaker: Mr. A. Davidson, Vice-President
German & Milne Inc.

1000 - 1015 COFFEE

1015 - 1115 Topic: Ice Transiting Performance - Ramming
Speaker: Dr. A. Nawwar, Vice-President
Arctec Canada Limited

Ice Transiting Panel:
Moderator: Mr. D. Hearnshaw, Chief Technical, Fleet
Systems, Canadian Coast Guard
Panelists: Mr. J.Y. Clarke, Director General, Fleet
Systems, Canadian Coast Guard
Dr. S.J. Jones, Head, Arctic Vessel Research
Institute Marine Dynamics, NRC

1115 - 1230 Topic: Ship Operations - From Research to Practice
Speaker: Mr. A. Sneyd, Manager of Research &
Development, Canarctic Shipping Company Limited

Ship Operations Panel:
Moderator: Mr. M. Audette, TDC
Panelists: Mr. W. Ellwood, Canada Marine
Transportation Administration
Mr. R. Lowry, Senior Scientist,
Intera-Technologies Ltd.

1230 - 1330 LUNCH RECESS

1330 - 1430 Topic: M.V. Arctic - The Challenge of the Future
Speaker: Mr. M. Luce, Executive Vice-President
Canarctic Shipping Company Limited

1430 - 1500 Closing Address: Dr. P. Camu, Chairman
Marine Transportation R&D Advisory Board.

OPENING ADDRESS

Mr. R.A. Quail, Administrator
Canadian Marine Transportation Administration

The address outlined the challenge of new goals for shared research and development in Arctic waters. The timing of the seminar, following on the federal government announcement of the most important initiative for Arctic sovereignty in a long time, was applauded. The speaker described the organization of the MV. Arctic Research and Development Program; Canarctic Shipping Company Limited as a member of an extended family of corporations; the funding of the program from the Marine Adminstrations funds for mission-oriented purposes; and the Canadian Coast Guard's major role in Arctic activities to support safe and efficient shipping in the hostile Arctic.

The speaker described the need for reliable technology to permit safe and clean operations in the Arctic. This technology will be costly, it will stress automation and will probably be satellite based. Some of it has already been tested in the Arctic summer but not yet in the dark Arctic winter. Continued and close cooperation between government and industry on both operational and R & D matters is required to continue the R & D program in the Arctic.

A brief history of the ship was presented. The MV. Arctic is the first purpose-built Canadian ore carrier for Arctic operations. It was built by Canarctic, a company established to construct, manage and operate the vessel. Canarctic is a consortium of the Federal government representatives of Transport Canada Marine Administration and Northwater Navigation. Northwater Navigation comprises Federal Commerce and Navigation, Upper Lakes Shipping and Canada Steamship Lines.

A twenty-minute film was then shown. The film was narrated by Mr. J. Grinstead of the Canadian Coast Guard (Northern). It presented many sequences of the MV. Arctic's operational activities including the first ever loading of a commercial oil shipment from the Canadian high Arctic.

OPENING ADDRESS

Mr. R. Mayes, Director General
Transport Canada, Research and Development

This presentation pointed to the value of the MV. Arctic as a research tool. Canada currently spends 1.3% of the gross domestic product on Research and Development. Of that, Transportation R & D accounts for 7.5%, with 10% of that amount directed towards marine programs. The government funding acts as a catalyst for effective R & D leading to technological development. In the area of Arctic R & D, Canada has the opportunity to excel. The MV. Arctic program provided:

- *a firm base for Canadian export*
- *technical transfer to Canadian industry*
- *help necessary to realize Canadian Arctic potential.*

The program was characterised by:

coherence - *in that from the outset the program was planned with clear research objectives*

commitment - *it reflected several multiyear programs: e.g. construction; TDC 7-year program, Arctic marine R & D program*

cooperation - *it is a joint government and industry venture.*

Results from the program already include:

- *new Canadian products in navigation aids, ice hazard detection and collision avoidance*
- *new methods for selecting routes and delivering ice configuration data*
- *an upgrading of traditional engineering capabilities to deal with higher class vessels and equipment.*

The speaker then listed the six objectives of the program as follows:

1. *to evaluate the Canadian Arctic Shipping Pollution Prevention Regulations*
2. *to evaluate the restraints on seasonal operation periods*
3. *to develop improved or more appropriate navigation and communications equipment*
4. *to correlate model and full scale tests together with establishing icebreaking efficiency*
5. *to establish the degree of effectiveness of special features*
6. *to provide an instructional base for future development.*

The phases of the program were noted with particular emphasis given to the fact that throughout the program extensive use was made of outside contractors. Hence, the body of knowledge and experience gained from the program rests largely in the private sector. The seminar will serve to complete the transfer of the program results to the private sector.

AN ARCTIC OVERVIEW

Mr. G.N. Faulkner, Assistant Deputy Minister
Indian and Northern Affairs

The theme of the presentation was the influence of past, current and future Arctic activities, policies, and issues on the demand for Arctic shipping. The audience was introduced to a global geography of the Arctic; its population and economic sections. The history of marine related developments from the Manhattan Project to the Lancaster Sound Green Paper was traced in relation to Sovereignty. The issue of complex policies sometimes in conflict relating to native, environmental and regulatory concerns was touched upon. The speaker advocated a streamlined policy and regulatory regime in this area where difficult physical conditions coupled with the need to be competitive makes transportation the key to development.

The economic development of the north was discussed in terms of: non-renewable resource development, e.g. minerals, and hydrocarbons, tourism (tour- ship through the northwest passage), and community supply. The summer shipping season is adequate for minerals, small scale hydrocarbon development, resupply and tourism but a significantly extended season is required for any large scale hydrocarbon activity.

The speaker listed the many issues for which policies are drawn, e.g. national objectives, markets, technology, sovereignty, native concerns, industrial benefits. Policies are frequently in conflict and there is a great need for coordinating mechanisms to ensure the most efficient use of available resources to meet the needs of Arctic development.

A major demand is expected to come from the hydrocarbon industry for efficient Arctic transportation. Marine and pipeline technology will compete for this work and the marine interests will be greatly challenged to improve current technology and develop new technology. The challenge is to move Arctic resources on a year-round basis with minimal or no environmental disruption.

MV. ARCTIC PROFILE

Mr. R.A. Dick, Vice-President
Melville Shipping Ltd.

The presentation described the MV. Arctic project from its concept stage in 1970 to the present day.

The initiation of this project, to build a vessel which would be more ice capable than any other commercial bulk carrier and would access the proposed lead and zinc mines in the eastern arctic, coincided with the Federal government's desire to promote the concept of Canadian vessels removing Canadian resources to markets.

Using slides to support the topic, the vessel was described in detail.

At present, the Royal Trust Company holds the financing and leases the vessel to Canarctic Shipping, who operates the vessel during the Arctic season and time-charters to Northwater Navigation during the non-Arctic season.

The speaker described the arctic operations of the ship during the eight years 1978 to 1985. The success of the vessel is underlined by the fact that it has met and indeed exceeded virtually all its design criteria. The MV. Arctic's initial design requirement was to navigate through level ice 0.6m thick at a speed of 2-3 knots. In fact, the ship navigates through ice thicknesses in excess of 2 metres. The design and operational mandate of the ship have been successfully met.

The research mandate was met when the ship was fully instrumented for research purposes under a program managed by the Transportation Development Centre. The effectiveness of this program is given in the technical presentations of the MV. Arctic Seminar. A film of a probe into Lake Melville demonstrated some of the research activities undertaken.

A major finding of the project from the speaker's point of view was the understanding that no one design condition describes a vessel for the arctic. Rather, there is a matrix of conditions that we are only now beginning to appreciate.

PROPULSIVE PERFORMANCE

Mr. R.A. Dick, Vice-President
Melville Shipping Ltd.

The presentation pointed out that although the program of data collection was directed towards the structural elements of the MV. Arctic, there was useful data from which propulsive performance could be inferred.

The propulsion sensing devices of the instrumentation system were reviewed and several examples or torque-thrust relationship were detailed. Analysis of these relationships resulted in several conclusions as follows:

- *transient torque and thrust peaks due to ice impact could reach a maximum of 2x mean level at maximum rating, well within current design regulations*
- *the peaks are of extremely short duration (the thrust peaks may be positive or negative) and have no effect on propeller efficiency*
- *ice interaction with the propeller is of the single impact type, there is no evidence of ice milling*
- *more instances of impact occur during broken channel operations and during pitch reversals.*

The techno-economical assessment of the propulsion system showed that there were worthwhile lifecycle advantages in favour of the system fitted to the MV. Arctic over a more simple, slow speed diesel/fixed propeller installation.

It was the opinion of the speaker that the propeller shafting and gearing of the MV. Arctic seem to have adequate strength, however, bending effects on the shaft and the thrust action on the gear-case may give rise to long-term problems and should be considered for future projects.

Q1. Can you give orders of magnitude of the number of load spikes due to ice impact on the propeller eg. 1/sec, 1/hour? Are there any hypotheses to explain the variation between the observations of shaft torque and thrust in an ice ingestion occurance?

A. It is difficult to speculate on why, when ice is ingested by the propeller, there are sometimes positive responses and sometimes negative responses in terms of thrust. There is no pattern to the reactions. We think possibly that the negative reactions are due to a blockage of the duct by ice, this would also explain a negative peak immediately following a positive. We could not see what was happening so we do not really know. It could be due to variations in waterflow but the duration of the peak makes this unlikely. It would be very difficult to actually observe what is happening at the propeller. As far as the MV. Arctic is concerned, it does not seem to be important.

The number of load spikes has no cyclic period as they occur so infrequently. There is no clustering during continuous forward motion. The ramming process presents some clustering but not enough to in any way affect the mean torque level nor apparently the efficiency of the propulsion system. The magnitude of fore and aft motion spikes are similar but the aft spikes occur at very low power levels.

Q2. *Could you comment on the possible use of CP propellers, with or without nozzles on ships with two or three propellers.*

A. *We went through this question in a fair amount of detail for years during the Arctic Pilot Project. We felt confident after our period of investigation that we could put CP propellers on high power ice going ships because:*

- *of the experience of the United States which was initially bad but now is very much improving*
- *our discussions with the propeller manufacturers and the work they were doing on high power systems*
- *we designed a whole ship rather than just a propulsion system.*

In a two-shaft installation, the outboard tips of the propellers would be closer to the center line of the ship than for a three-shaft installation hence they would have better protection. However, individual shafts of a 3-shaft system would probably operate at lower powers.

Q3. *You have stated that the regulatory design torque was found to be about 1.7 times the average torque. You suggested that this proved to be an excessive safety margin in your opinion. However, you did acknowledge that the frequency of high torque values in the MV. Arctic seemed related to its long hull length. Taking into account that the regulations must ensure a sufficient factor of safety, how would you suggest the present regulations be amended?*

A. *When I said 1.7 times mean torque, what I should have said is that when it is calculated the regulations call for approximately 1.67 times maximum continous rating torque rather than average torque. I did not mean to say that I thought this was an excessive margin. When you consider the torque levels we actually found, the regulation is adequate for the interaction experienced by the MV. Arctic. I think that the values as a level is adequate, however. Whether or not that is the way the regulations should be written to govern the design of a ship such as this, I think probably not. We have come to recognize that the magnitude of these levels and the importance of them is related to the rest of the ship. We cannot design the propulsion system in isolation.*

Q4. Have any mathematical models of the power train been constructed for the MV. Arctic and, if so, with what results vis-à-vis actual measurements.

A. The only mathematical model prepared for the propulsion system was when our client, TDC, asked us to speculate as to what effect ice loads would have on the propeller itself, on the mechanism of the CP propeller. We put together a mathematical model of the effect of the ice on various parts of the propeller and speculated on the importance of these levels. No mathematical model was made for the whole system.

Q5. Could you elaborate on the idea that this experience leads to electric propulsion?

A. The information generated by this program does not suggest that electric propulsion is required for ships of the MV. Arctic type. However, larger vessels, particularly those with open propellers, i.e. no ducts, may have loads that require electric propulsion. Gearbox technology for higher powers expressed as higher torques is not proven, hence their ability is questionable. It would depend upon the confidence of the designer as to whether he would chance a gearbox or go for the relative safety of electric propulsion.

STRUCTURAL PERFORMANCE - LOCAL EFFECTS

Mr. I.Glen, President
Arctec Canada Ltd.

The objective of the work covered by this presentation was to evaluate the structural strength requirement of a Class 2 vessel, and in particular to offer an appraisal of the current regulations as manifested in the form of the structural design of the vessel, and to provide a basis for further development of ice navigation expertise. The presentation described how the vast quantity of data available from the instrumentation system was categorized and analyzed. Categories of operations included voyages, operating in multi-year ice, ramming, level, first year ice, 10/10th cover of first year ice and turning. The ice condition information ranged from fully documented and/or observed to poorly documented. The ice loads and presssures calculated from the strain data measured revealed that:

- *level ice transit gives the lowest loads*
- *operation in multi-year ice offered the most severe loads*
- *risk of exceeding CASPPR design pressures while transiting in level ice is negligible.*

In the area of hull strain, the speaker presented many illustrations to support the findings that:

- *the strains measured in the plates and frames are similar*
- *strain rates experienced are not critical to crack propagation.*

Stress profiles were presented and were seen to vary with the mode of operation of the ship. The various failures were discussed but since not all were captured on tape, the only general statement made was that they all occurred during operations in multi-year ice. The speaker suggested that based on the experience of the MV. Arctic, it would be more appropriate if the regulations were based on multi-year ice rather than continous level ice. The speaker ranked the conditions that affected the hull the most as:

1. *operating in multi-year floes where mean pressures measured were 2.5 times the level ice pressures*
2. *broken channel*
3. *ramming*
4. *turning in level ice*
5. *transiting forward in level ice.*

Q1. Accepting that the small area pressures were not calibrated, can you speculate on why the magnitudes were so low when compared to other sources?

A. I should just recap what the small area was. In the middle of a large panel that had been calibrated, there was one interframe panel that

had approximately six gauges on it. So my first comment is that you are trying to seek several unknowns; magnitude of the pressure, size of the pressure which is two-dimensional and the shape of it. Additionally, you have several unknowns some of which are boundary conditions. Since we did not have a model for these, we did not have a calibration for it. There were not sufficient gauges along the length of the plate to paint a stress profile. We could speculate as to what the boundary conditions were but we could well be out by a factor of 2 because there was not enough data to clearly define what the plate was doing in terms of end fixity etc.

Q2. Where stresses are reported are they stresses at point of measurement or maximum stress in local structures due to recorded incident. In other words, is there known to be or likely to be much difference between them?

A. The stresses reported are the stresses at point of measurement and in most cases, the strain gauges were placed where one would expect to find the maximum stress.

Q3. If those pressures are over $3m^2$, they are relatively high. The pressures indicated for transiting multi-year ice appears fairly high. Are these pressures over one plate panel? If not, what area are they related to? Do you have any opinion as to how these pressures would compare with those that might occur in glacial ice?

A. Generally speaking, the peak pressures talked about were over an area considerably bigger than one plate panel. If you think of the area that I talked about as a load panel, that section with a grid of gauges on it. The strain gauges were on the middle between the web and the frame. They are 1.5m apart so the area of each strain gauge is $1.5m^2$. How does it compare with glacial ice? With a bit of luck this fall, we will have results from the Polar Class on that.

Q4. How does the result of our research on structure compare with known research by the Finns. Has there been any effort to compare our methods with those of Finland?

A. Yes. Many joint programs are going on. Knowledge is pooled to the extent permitted by our client Transport Canada.

Q5. Intuitively, one might have expected ship/ice interaction to be more severe in multi-year ice; broken channel and ramming. Would you speculate as to the reason for the statistics showing a 40% increase in the severity when turning in level ice as compared to straight ahead level ice operation. Could you possibly link such speculation

to the higher frequencies of contact experience while turning, a factor of 5 was quoted.

A. *I believe it's wholly a function of non-optimum angles and the ice failure mechanisms involved.*

Q6. *Do you have sufficient information to establish a relationship between the bow shape or water-line curvature and a function of the pressure?*

A. *Unfortunately not. The hull angles along the water-line where the gauges were deployed did not change enough to get a trend.*

STRUCTURAL PERFORMANCE - GLOBAL EFFECTS

Mr. A. Davidson, Vice-President
German & Milne, Inc.

This presentation put forth the thesis that a field test program coupled with mathematical modelling provides confidence that the global forces generated during impact with infinite ice floes of an ice breaking bulk cargo vessel and the associated hull girder primary and secondary structural responses can be predicted. The speaker described the global effect as the response of the primary structure remote from the area of direct contact. The factors affecting the response are ship speed, shape, and structural configuration and ice characteristics. A dedicated test program was described whereby a series of field tests using the MV. Arctic was executed in conjunction with mathematical modelling of the ship. The activities of the program included pre-trial mathematical modelling, field tests and post-trial simulations. The specific goals of the program were:

- *to determine global bow force and associate time dependency over a speed range up to four knots,*
- *to determine hull girder stress related to bow force and ramming speed,*
- *to determine ship motions during ramming.*

The pre-trial analysis dictated that for safety reasons the maximum speed be set at four knots. The trial results demonstrated that, up to the four knot speed, force is linearly proportional to ship's speed during a ram. Characteristic curves were presented to illustrate the ship's motion during a ram.

The results of the program indicated that designers have in mathematical modelling an analysis tool which enables them to assess the structure of vessels over a limited operating range. Furthermore, designers can predict performance with a certain degree of confidence. It is not yet appropriate to extrapolate the findings up to speeds of say 12 knots. Operators are now able to reduce the risk of arctic shipping thus improving the potential for profitable arctic operation.

Q1. What was the extent and location of the damage during the trial?

A. I was not on the trials and do not know specifically. I understand it was a modest tear, forward.

Q2. What formula could be developed for trials from the total global hull design loads perhaps as a function of displacement, ship velocity and so forth as a result of the trials or simulations todate. What would be the force at high impact velocities?

A. It is probably a bit premature to extrapolate forces for such phenomenon at this point in time. No formula as such is postulated in the report. No particular work was done in that area.

Q3. How many repeated rams were made into the same notch. Is your finding of ram 131 that higher midship stresses were experienced in a second ram consistent for all repeated rams ?

A. Those answers are contained in the report, I do not have specific figures at hand.

Q4. When is a floe infinite? How is it determined and how can we extrapolate for larger vessels?

A. In modelling, the motion of ice and vessel have to be taken into account. You could probably say that the floe tends to be infinite when the kinetic energy of the vessel is rapidly absorbed by the ice and that the combination of ice and vessel has zero velocity displacement.

Q5. Medical practice is said to be 80% science and 20% art. By comparison, how do you rate global analysis?

A. 60% science and 40% art and getting better every day!

ICE-TRANSITING PERFORMANCE: CONTINUOUS MODE

Mr. A.C. Albery, Senior Partner
Albery, Pullerits, Dickson Associates

The presentation identified the four elements of the continuous-mode study program as follows:

1. *to study the master data package, scanning the vast number of nine track tapes to determine what was useful and relevant data and to extract that data and plot it on a time base.*
2. *to reduce and summarize the data and determine the relationship of the plots of thrust, torque, ship's speed, shaft rpm and propeller pitch, to the ice resistance in relation to the ice thickness and the speed of the ship.*
3. *to review existing research on resistance of ice to the motion of a ship so as to develop a formulation to represent the performance of the MV. Arctic.*
4. *to comment on certain aspects such as hull geometry, effectiveness of the bubbler system, power requirements of the Canadian Arctic shipping regulations and the correlation with the model tests.*

The speaker noted that only continuous sheet level ice was considered during the study. The difficulty in obtaining ice properties and an unreliable Doppler speed indicator were also cited as difficulties encountered.

The forms of ice resistance predictor equations based on those of Kashtelyan, Enkvist and Poznyak were displayed and a step-by-step explanation of the modification to each equation for the current study was given. The major consideration for modification stemmed largely from the vastly different hull dimensions of the MV. Arctic when compared to those of a conventional icebreaker. The conclusions reached demonstrated that with 11,000 kw power in 1 metre of ice, speeds of just under 2 knots would be attained; in 0.75 metres the speed would be just over 5 knots; and in 0.5 metres of ice the speed would reach almost 10 knots. It was felt by the researchers that the performance would be enhanced by a bow shape presenting a greater flare. The findings showed that the MV. Arctic had ample power for transiting continuous level ice but was somewhat short on power in pack ice of 9 or 10/10 ... and 1 metre thick. There was good correlation with the 1974 model predictions of performance.

Q1 Would the speaker care to comment on the relative importance of good ice information on the determination of performance. Particularly as related to significance of friction factors assumed or derived.

A. It is well known now that friction has a tremendous effect on the resistance of a ship in ice. It is extremely important to determine the friction of the vessel with or without a low friction coating.

From an extensive literature search, data on only four low friction coatings was found. Using these methods, a value of 0.03 was used as the coefficient of friction for the MV. Arctic.
The need for good ice information depends largely on the researcher's opinion as to the right sort of equation to use for representing performance. If a Kashtelyan type is used, ice strength but not strain modulus, may be in error. However, if a Carter-type equation is used, ice properties are extremely important.

Q2 *Having stated at the outset that the quantity and quality of the MV. Arctic data was low, what justification was there for the detailed manipulation of previous resistance equations that are based on significant data bases?*

A. *If you can use a previous equation and adapt it also to fit the MV. Arctic, you have a greater feeling of the reliability of the resulting equation. In adapting these equations, we employed a systematic process for testing and adjusting the coefficients so that they still fitted the data upon which the equations were originally based. We allowed for the fact that the MV. Arctic had greater length and draft.*

Q3 *Have any observations been made of the effect of other parameters of ice other than thickness?*

A. *A large body of literature exists on other observations of ice properties. For instance, the relationship of strength and Young's modulus to salinity and temperature.*

Q4 *Considering that it is very difficult to obtain reliable ice resistance data reprsenting the active icebreaking condition, would it be possible to determine the elastic modulus by acoustic or seismic methods and then to correlate this value with flexural strength since both vary with the same parameters? (Question directed to panelist S.J. Jones.)*

A. *The measurements taken in the field are flexural strength and Young's modulus. The relationship between them is a ratio, typically of the order of 5000, however, this varies widely. A ratio of 1000 is considered very low. Modeling ice to scale down both strength of ice and Young's modulus is very difficult. The questioner's idea might well have good validity for further consideration.*

Q5 *In view of the accuracy of measuring ice thickness and strength, the lack of data and errors in speed recording, could you set some confidence levels on the equation that has been developed?*

A. *The ice thickness and strength measurements were quite good. The unusually low Young's modulus found in the Lake Melville trials was probably due to the fact that it turned very warm during the trials. For the range of data we have and using the equation we adopted, our conclusions give a reasonable representation of performance. Care would have to be taken if our results were extrapolated for defining other conditions or for other vessels.*

Q6 *The work undertaken was to analyze the data from the MV. Arctic and draw conclusions concerning the ship's level ice performance by comparing the predictions, propulsive effectiveness, etc. What really were the conclusions of the study?*

A. *The performance was as shown on the slides in terms of ice thickness and speed. Propulsive effectiveness was not part of our terms of reference. The only predictions made were those resulting from the model tests. These were done on a basis of slightly reduced power and the assumption of greater ice strength and greater friction resulting in the prediction that the MV. Arctic could maintain a certain speed through 2 feet of ice. If you take into account the lesser power and the greater friction, then I think that there is no particular disagreement between the model tests and the full scale predictions.*

ICE-TRANSITING PERFORMANCE: RAMMING-MODE

Dr. A. Nawwar, Vice-President
Arctec Canada Ltd.

The presentation identified the two main objectives of the ramming-mode study as follows:

- *to establish the ramming-mode performance capability of the MV. Arctic and the effect of various design features on this performance;*
- *to provide some means of performance simulation which permits the use of the findings of the MV. Arctic study to predict the performance of the ship under other conditions and to extend the results to other ships.*

An account was given of the ramming-mode formulations which included resistance models, performance formulations and ship motions or accelerations. From the 70 hours of ramming data collected, the MV. Arctic performance was analyzed and simulated. The analysis included the effects of acceleration distance, speed of impact, thrust cut-off, ice thickness, bubbler operation, trim condition and power level on performance. The speakers illustrated the fact that there is an optimized ramming cycle, and a ram achieving an optimum impact speed offers a 2.5 times saving in fuel for distance travelled as well as a 70% improvement in advance time over a poorly executed ram. The conclusions of the study were stated as follows:

- *the MV. Arctic performance was closer to Class 4 than to Class 2*
- *the speed of impact versus the speed of advance has an optimum value*
- *the effect of the bubbler system on the resistance is similar to that of bow trim*
- *fuel consumption increases exponentially as ice thickness increases*
- *the capability limit of the MV. Arctic is 3.6m of ice thickness*
- *the capability of the vessel in ridges is dependant on the thickness of the surrounding ice*
- *there is a transition point above which it is more fuel efficient to ram than to break the ice in a continuous-mode.*

Q1. Would a member of the panel care to comment on the presentation? (Question directed to panellist J.Y. Clarke.)

A. The effectiveness of icebreaker operation is affected by the skill and judgement of the Master in the global sense and the individual techniques employed. It would seem that we could learn from personal judgement on the one hand, and from the actual optimum performance equations on the other. I would like to look at these findings more closely to come up with some guidelines or training session on ramming that might be included in the Coast Guard command course.

Q2. It was interesting to note that the optimum speed for ramming thicker ice was lower than that for thin ice. This appears to run counter to expectations. Could the speaker comment on why this should be the case?

A. Intuitively, if you are ramming in very thick ice you are meeting increased resistance to the ship motion in broken ice because the ice is thicker and becomes more difficult to displace under the ice cover. You have a higher concentration of ice in the broken channel, hence you have higher resistance and thus cannot attain higher impact speeds. In thin ice, higher speeds are attained. Optimum speeds are lower in thick ice.

Q3. The tests were carried out with a speed limit imposed of 4 knots for safety reasons. Did this affect the conclusions relating to ram impact speeds?

A. There was no speed restraint for the 1979-1981 data collection period covered in this study.

Q4. Given the data base which was reduced, what are your views on a semi-automatic control of the ramming cycle for ships such as the MV. Arctic?

A. Semi-automatic control is possible, we have the technology and it would be an enormous advantage for commercial ships such as the MV. Arctic where schedules and mission profiles are important financial considerations. We might even consider a fully automatic ramming cycle. The MV. Arctic with its potential for arctic operation would make an ideal platform for building and testing such a system.

Q5. Does the ultimate ramming performance of 3.6m of ice apply to the performance from a single ram. Did the author look at the performance for a multiple ram senario? Is 3.6m the maximum thickness the ship could accomodate in progressing?

A. We extended data from two groups of data - one at 1.5m and one at 2.5m to make the prediction of 3.6m maximum. The MV. Arctic is not an icebreaker, it is a commercial cargo vessel and we believe that attempting ice thicker than 3.6m would be uneconomical. We do believe that this upper limit could be extended through the use of auxilliary systems.

ICE-TRANSITING PERFORMANCE: MANOEUVERING MODE

Mr. A. Davidson, Vice-President
German and Milne Inc.

The objective of the manoeuvering study was to extract the relevant data from the tapes, review it, and determine if a conclusion could be drawn relative to manoeuvering. The specific performance considered was:

- *the directional stability of the vessel (course keeping)*
- *the turning performance*
- *the adequacy of the strength of the steering gear*
- *the impact of the bubbler system on turning ability.*

The population of data studied represented 18 to 20 turns with the bubbler system off in ice thicknesses ranging from 0.1 to 1.0 metres; and 14 turns with the bubbler on. The presentation illustrated that:

- *the ship had good directional stability (eg. the operator was required to apply $\pm$ 7° to 8° of helm to maintain a heading of $\pm$2° in level ice);*
- *the ship has moderate turning ability in ice (in open water, it required 2.5 ship lengths to turn; in 70 cm of ice, it required 15 ship lengths). There is a linear dependency between ice thickness and the radius of turn;*
- *the bubbler system substantially improved the turning performance (reducing the number of ship lengths required to turn in 30 cm of ice from 7 to 3, and in 90 cm of ice from 18 to 13);*
- *the steering gear suffered no damage during the study.*

The speaker determined that the designers should specify the manoeuvering requirements for commercial vessels transiting ice in terms of turning radius or turning moment at low ice speeds.

Q1. When turning was the bubbler operating on both sides or one the side of the turn or on the opposite side from the turn? What was the effect of the bubbler on turning?

A. The bubbler system was operating on both sides, port and starboard, during the turns conducted with the bubler on. With respect to effect, it was fairly dramatic. In thin sheet ice, there was a 50% reduction in turning radius, in thick sheet ice there was a 20% reduction.

Q2. Earlier you said that ballasting had been done to create a list in the vessel during manoeuvering. Would you give us more information on the idea of putting a list on the ship to assist turning.

A. The one data point we have on the slide showing turning performance indicated that there was 5° of heel in combination with the bubbler. We can not separate the effect of the bubbler from the 5° heel in that instance. It would seem from other data available that the heel made a fairly substantial contribution to the turning performance.

SHIP OPERATIONS - FROM RESEARCH TO PRACTICE

Mr. A. Sneyd, Manager Research and Development
Canarctic Shipping Company Limited

The presentation elaborated on the research and development program of Canarctic and how it relates in a very practical sense to the operation of the vessel. The guiding principle behind Canarctic's R & D program is to develop a proven year-round capability for commercial marine transportation operations in the Canadian Arctic. The objectives are:

- *to demonstrate Canarctic's leadership in commercial capability;*
- *to develop technolgies in Arctic navigation which commercial activities have shown to be necessary for year-round operation;*
- *to extend that period of Arctic activity by adopting new technologies and operating practices developed through the company's research initiative.*

This research program is also driven in part by the current major upgrading of the vessel from both an ice capability and a cargo carrying perspective.

The speaker pointed out that in 1985 the vessel operated in Arctic zones 6 and 13 and was also given access to zone 1. After upgrading, it is expected that the vessel will operate unescorted in zone 1 and the season in zone 13 and 6 is expected to extend from as early as late May to as late as January or February.

In order to advance the focus on year-round operation, Canarctic's program has three subsections: arctic operational development; arctic environment; and, the commercial arctic ship development. In the areas of operations development and the environment, it was pointed out that the conventional approach has serious drawbacks. In Lancaster Sound in October and November, the ship met light levels she was not prepared to handle and an ice environment that was not fully understood.

Snow cover renders helicopter forays for visual data useless. Traditional ice charts do not offer the accuracy required for navigation. Traditional marine radar and display is not adequate. The current research program defines a three level plan for each voyage. The first level uses satelite imagery covering 1000 km to develop a stratcgic plan. The second level develops tactical information based on airborne radar which monitors and plots the vessel in ice over a 10 to 200 km range. The third level uses marine radar for close range avoidance.

The speaker acknowledged the close cooperation of both government and industry with Canarctic bringing on-stream practical navigation systems that are being refined and developed for marine use.

Q1 What research is being performed on dock facilities to ensure docking of the vessel?

A Some people are looking into ice management. We feel that there is a need for an engineering study to extend shore loading facilities, to ignore the ice and go over it. We want to look at the whole range of possibilities.

Q2 How does all this work in 24 hours of darkness? What is the reliability of the equipment?

A We do not know about 24 hours, we do know about 18 hours. The ship's operator comes to rely almost entirely on blind pilotage. As confidence in the new equipment grows, less time is spent at the window and more time reading the instrument displays. The reliability is not yet 100%, partly due to the problems of emerging technology and partly due to ship environment. We are working on this.

Q3 Is it feasible to fit a SAR system to commercial transatlantic jets for regular daily and supplemental ice data?

A Certainly, it is possible but it is not practical. The dedicated system includes the aircraft and each element of the system is required for the best quality information.

Q4 Shore-based, fixed-wing aircraft are expensive. Should the vessel carry a helicopter for navigation instead?

A For winter navigation, a helicopter is inappropriate for any operation in darkness. Additionally, snow cover precludes reliable visual observation.

MV. ARCTIC: THE CHALLENGE OF THE FUTURE

Mr. M. Luce, Executive Vice-President
Canarctic Shipping Company Ltd.

The presentation gave an overview of the vessel's operational experience and traced a number of milestones achieved by the MV. Arctic during the first eight years of operations. The achievements of the vessel were described as follows:

1978 - delivery of the vessel and three arctic voyages
1979 - season extended by a late season voyage to Churchill in mid-November
1980 - MV. Arctic performed one of the largest sealifts to move into the Canadian Arctic when she lifted the major portion of materials to construct the new Cominco Polaris mine facility
- a second late season voyage to Churchill
1981 - season extended to full Class 2 season in Zone 13
- in five consecutive voyages the vessel moved entire Nanasivik production to Europe
1982 - first commercial concentrates shipment out of Polaris
- vessel loaded two weeks before official opening of Class 2 season in Zone 6.
1983 - five scheduled commercial voyages
- extended late season to November 12 loading at Nanasivik
1984 - five scheduled commercial voyages
- achieved earliest commercial vessel transit of Baffin Bay
1985 - first commercial voyage into Zone 1
- took first commercial oil cargo out of eastern Arctic

The operation of the vessel in extensive ice regimes has forced the development of techniques and technologies to provide reliable commercial operations in ice. To retain our leadership role, both the cargo carrying capability and the ice capability of the vessel are being improved.

The OBO (oil-bulk-oil) conversion of the vessel was described and illustrated. This conversion included increasing the number of holds from five to seven, providing a cargo pumping system, gas tight hatch covers, an inert gas system, and other safety and ballast systems required for a new tanker. The ice class upgrading was also described and illustrated. A new bow is being constructed and the structural steel used on the ship's side is being strengthened and upgraded. When this work is completed, the ship will have Class 4 equivalency.

A new instrumentation system is being installed for performance and safety monitoring by the operator. It also has the capacity for sensor additions for extensive research data collection.

The challenges of the future are firstly, to extend the present commercial role of the ship, for the benefit of our existing customers and secondly, to provide a platform for research operations that will launch the next phase of Arctic marine research. The vessel's extended operating season will open up an opportunity to access Lancaster Sound during the winter period of total darkness. Developing the technology to operate successfully during this period is seen as the key to year round operating capability. The next phase of research will be a concerted R & D effort to address all of the problems associated with operating during this period using MV. Arctic as the basic test platform. A winter research program is being developed to address and test the technology goals outlined by the previous speaker.

Past achievements have been the result of close and continued cooperation of many interest groups. A continuation of this co-operational effort is needed to ensure that the challenge of breaking new frontiers is a shared activity.

CLOSING ADDRESS

Dr. P. Camu, Chairman
Marine Transportation Research and Development Advisory Board

The address thanked the speakers, moderators, panelists, and organizers of the Seminar with a special mention of Transport Canada for their confidence and leadership in the program. It was pointed out that, historically, leadership in the marine field has been more forthcoming from the public sector than from the private sector, and that a change in this weighting would be welcome.

The role of the Marine Transportation Research and Development Advisory Board was described as a forum whereby the private sector has a major input into the shipping activities regulated by Transport Canada. This advice is heeded over a full range of concerns from R & D thrusts to budget cuts.

The magnitude of the Arctic Research program was described in terms of the $12 to $15 million it has already consumed. Once the vessel enhancement is completed, additional programs in research, development operations and maintainance will go forward. The operation of a Class 4 vessel will take Canadians to areas never before accessible by sea and will extend the navigation season in the Arctic to enhance the commercial benefits of Arctic operations.

The major benefits of the Arctic program were described as:

1. *advancement of Arctic excellence;*
2. *an increase in the degree of confidence Canada possesses to meet Arctic challenges;*
3. *encouragement to investors and an insurance of our future frontiers; and*
4. *the improvement of operational and commercial effectiveness of Arctic cargo ships.*

Dr. Camu then presented the audience with the challenge to "provide Transport Canada with advice on how to approach the future". He further commended several articles to the audience for close study. They were:

- *International technological developments in the field of marine transportation, May 1985, Transport Canada TP. 2753.*
- *Islands in search of oil in the Beaufort Sea, NRC Science Dimensions, 1985, 3rd Quarter, National Research Council of Canada.*
- *Freedom to move: A framework of transportation reform. Policy paper by the Minister of Transport, TP. 6678 Canada, ISBN 0-662-14172-5.*
- *Task force on deep sea shipping. (Recommendation 5b) Report to Minister of Transport. April 1985. TP. 6347E Canada. ISBN 0-662-14071-0.*
- *Marine Traffic in Canada: Trends and Prospects 1985. TP. 6445 Canada.*

The Address was concluded by the formal closure of the Seminar.